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Abstract

UO_2 FUEL ELEMENTS SHAPED AS SMALL SPHERES

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In connection with a type of reactor design under investigation at the Technological Laboratory of CISE, a research programme on the manufacture and the characteristics of small, coated UO_2-spheres (1 ÷ 4 mm in diameter) has been carried out during the last two years. Those fuel particles might be generally in any reactor design involving the use of fuel as fixed or fluidized bed.

The following manufacture procedure has been developed for the spheres: adding to the UO_2 powder a solution with binding agents (the solvent can be water) a paste is obtained which is grinded in a ball mill. Part of the solvent having been evaporated, a bar is manufactured by extrusion. This is subdivided into small cyclinders which are placed in vibrating small cells (one cylinder in each cell) for 3 to 4 minutes. By knocking against the walls of the cavity the particles assume a spherical shape. A standard procedure is used to sinter these spheres.

Up to now only a Ni-Cr coating has been studied. First a 5μ thick Ni-layer is deposited chemically on the UO_2 surface, to which it adheres very well. A second 10 μ Ni-layer is then deposited by means of an electrolytic process. Eventually a third Cr-layer, 10 μ thick, is electrolytically deposited. After a successive 850°C annealing for 5 hours, a Ni-Cr alloy is obtained.

In order to study the strength to thermal stresses, like those present during the reactor operation, a testing procedure has been developed in which the spheres undergo a thermal shock. They are first heated up to a temperature T_o, then quickly cooled down with a blast of steam and water at a lower temperature $T_o < T_o$. For the detection of any possible damage, the spheres are examined by using proper detectors.

The presence of small cracks indicates that the critical temperature difference has been exceeded. By knowing the critical temperature difference, many interesting physical properties of the material can be derived. For these tests uncoated UO_2 spheres are used.

The coating has the essential purpose of preventing the oxidation of UO_2 into superior oxide compounds by the hot water and the suitability of the Ni-Cr layer to protect UO_2 was checked by tests in autoclave.

A first series of tests yielded very positive results: no surface damage was detected. A new set of tests, with a much longer exposition time, are currently under way.

An in-pile technique is now being studied for the measurement of fission gas release from the spheres.

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Abstract

PREPARATION OF DENSE PARTICLES OF THORIUM AND URANIUM OXIDES

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A method for the preparation of dense thorium and uranium oxide particles which does not require the use of high temperatures, except for the final firing step, was investigated.

The method was based on the trend of thorium and uranium salts to form spatial micromolecules, when in very concentrated solutions and in highly acid-deficient conditions.

Depending on the water content, the anion/cation molar ratio and the preparation process, a product ranging from a colloidal suspension to a more or less fluid glassy gel is obtained.

In the step of a very fluid gel, the product can be shaped (in the form of small spheres, for instance) and consolidated by further water or anion withdrawal and/or by a partial satisfaction of the remaining anions.

Lastly, upon firing, dense particles with peculiar features are obtained (for instance the thorium oxide particles look transparent under the optical microscope).

Details regarding a method of producing concentrated uranium (IV) nitrate solutions (which can be one of the starting products), their stability against oxidation and the analytical control methods are supplied.

The preparation and control methods for the fluid gels to be shaped are briefly reported.

The shaping of the spherical particles and the most important properties of the fired final products are outlined.